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THREE SPECIES OF THE GENUS *ZAUS* (COPEPODA,
HARPACTICOIDA) FROM KODIAK ISLAND,
ALASKA

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With Text-figures 1-15, Table 1 and Plate 1

The present paper deals with three *Zaus* species, one of which is new to science, found in a sample of algal rinsings which was collected at Narrow Cape on the east side of Kodiak Island, Alaska, by Mr. K. Hirano of Hokkaido University. Taxonomy within the genus had long been confused due to the presence of some inadequately described species as well as dubious records (see revision by Lang, 1965), especially connected with *Z. aurelii* Poppe, 1884, *Z. caeruleus* Campbell, 1929, *Z. intermedius* Nicholls, 1939, *Z. serratus* Monk, 1941, and *Z. schäferi* Klie, 1949. Since, in those species, *Z. intermedius* was re-described by Itô (1974), and *Z. aurelii* is reported in the present paper together with a full re-description, the confused status within the genus will fairly clear up.

Description of the coloration is based upon observations on formalin-preserved specimens. Dissected somites and appendages are mounted on slides with gum-chloral medium. The type-series is deposited in the Zoological Institute, Faculty of Science, Hokkaido University.

Before going further, I would like to express my sincere gratitude to Professor Mayumi Yamada of the Faculty of Science, Hokkaido University, for reading the manuscript. Sincere thanks are also due to Mr. K. Hirano of the Faculty of Fishery, Hokkaido University, who gave me this interesting material at my disposal. The electron microscope study was carried out with kind assistance of Mr. Y. Nodasaka of the School of Dentistry, Hokkaido University, to whom I am much obliged.

Zaus aurelii Poppe

(Figs. 1-6)

Zaus aurelii Poppe, 1884, p. 286, pl. XX, figs. 7-9, pl. XXI, figs. 5-15. Synonymy and previous records are discussed later.

Female. Body (Fig. 1, 1) 0.80 mm long, rostrum and furcal setae excluded, and about 0.5 mm wide. Rostrum (Fig. 1, 2) bending downwards, somewhat wider than long, with two pairs of sensillae (see Pl. I, fig. 1). Cephalothoracic somite tintured with dark brown at each lateral hind corner both dorsally and ventrally; a square purple patch above nauplius eye; an arched, laterally stretched brown patch on dorsal surface.

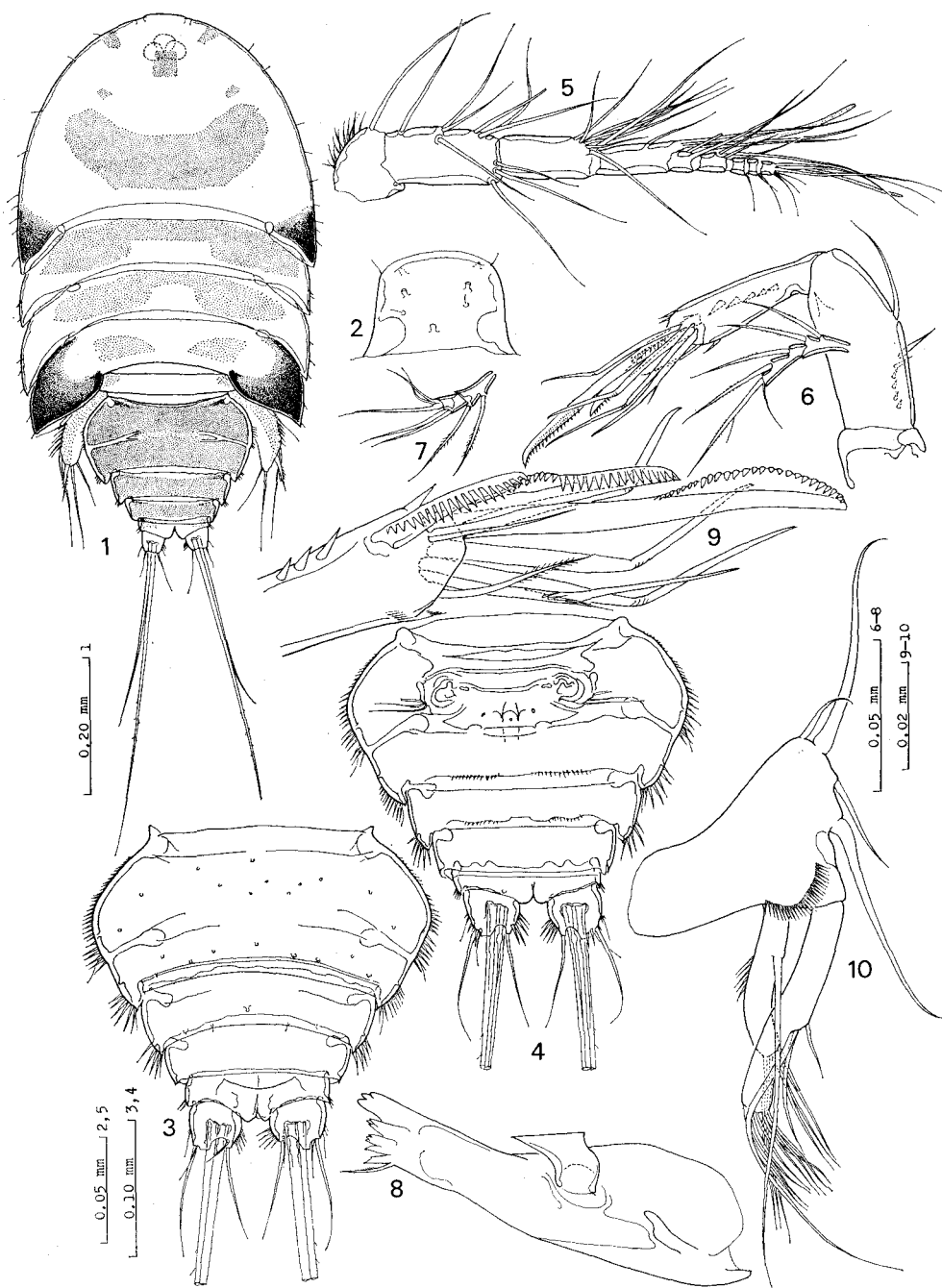


Fig. 1. *Zaus aurelii* Poppe. Female (9, 10: a separate specimen). 1, habitus, dorsal; 2, rostrum; 3, abdomen, dorsal; 4, ditto, ventral; 5, antennule; 6, antenna; 7, exopodite of right antenna; 8, coxa-basis of mandible; 9, last endopodite segment of antenna; 10, coxa-basis and both rami of mandible.

First two free thoracic somites tintured with light brown. Third thoracic somite tintured with very dark brown on both dorsal and ventral surfaces of lateral part. Abdomen brown. Each epimeron of first three thoracic somites (Fig. 2, 1-3) with three sensillae, of which the anteriormost one is spine-like, and some scattered secretory pores. Abdomen (Fig. 1, 3-4) shorter than cephalothorax, acutely tapering posteriorly, 0.25 mm in greatest width. Genital double-somite subdivided by a chitinous suture ventrally and laterally, with numerous secretory pores on dorsal surface, two closely set setulae on both lateral limits of genital area; lateral edges densely spinulose; some delicate spinules along ventral hind edge. Antepenultimate somite with a few secretory pores on dorsal surface, some spinules on lateral edges and some delicate spinules along ventral hind edge. Penultimate somite with no spinule. Anal somite about 0.1 mm wide, with a few spinules on lateral sides. Furcal ramus almost as long as wide, with a basally geniculate setula on dorsal surface near inner end, one seta on posterior inner edge, a fine setula on the middle of outer side, two close setae on outer side near posterior end; principal terminal setae well-developed. *Antennule* (Fig. 1, 5) nine-segmented; sixth segment a little longer than fifth. *Antenna* (Fig. 1, 6). Coxa short and bare. Allobasis about 2.5 times as long as thick, with a short seta on almost middle anterior surface and a row of thick spinules on proximal half of antero-inner surface. Endopodite somewhat shorter than allobasis, with a longitudinal row of stout spinules on inner side, three pectinate spines (see Fig. 1, 9), four elongate spines, of which three are geniculate midst, and two setulae on distal end or subdistal edge. Exopodite consisting of two segments of an equal length; first segment with two setae, second one with two lateral setae and one terminal seta which is accompanied by a bare setula close to its base and has a hair-like branch. Exopodite of the right antenna (Fig. 1, 7) is aberrant. *Mandible* (Fig. 1, 8). Praecoxa sclerotized, well extending inwards; pars incisiva tridentate. Coxa-basis (see Fig. 1, 10) markedly widening distally, with two setae, of which the inner one is very short, on inner distal corner and two setae, each arising from a ledge, on distal edge; an arched row of a number of spinules near outer distal corner. Each ramus consisting of a cylindrical segment inclined outwards. Endopodite about 1.5 times as long as exopodite, with three setae on a ledge at the middle of outer (ventral) side and two sets of four (?) juxtaposed setae on distal end. Exopodite with one long seta arising from a point at proximal one-third of the length of outer (ventral) margin and four and three juxtaposed setae on distal end; some narrow spinules on outer margin. *Maxillula* (Fig. 2, 4). Arthrite of praecoxa furnished with an arched row of minute spinules on posterior surface, two parallel setae on anterior surface, at least eight more or less spinulose claws along inner edge and two thick spinulose setae on dorsal edge near inner end; a few close spinules on the middle of dorsal edge. Coxal process reaching the middle of arthrite of praecoxa, terminating in three setae, furnished with spinules near its tip. Basal process about twice as long as coxal process, with two close setae on dorsal edge near apical end where four setae arise; some spinules on dorsal edge. Endopodite represented by a cylindrical segment, inclined inwards, with three bare setae apically or subapically; some fine long hairs along ventral margin. Exopodite segment thicker than endopodite, inclined

ventro-outwards, terminating in one very thick seta which is fringed with some long hair-like spinules; two bare setae each arising from posterior surface of the terminal thick seta and subdistal inner edge; one plumose seta arising from a ledge at three-quarters of the length of inner edge; inner margin densely fringed with numerous long hairs; outer margin with some long and narrow spinules. *Maxilla* (Fig. 2, 5; see also Fig. 2, 7). *Syncoxa* ornamented with three almost cylindrical endites each terminating in three

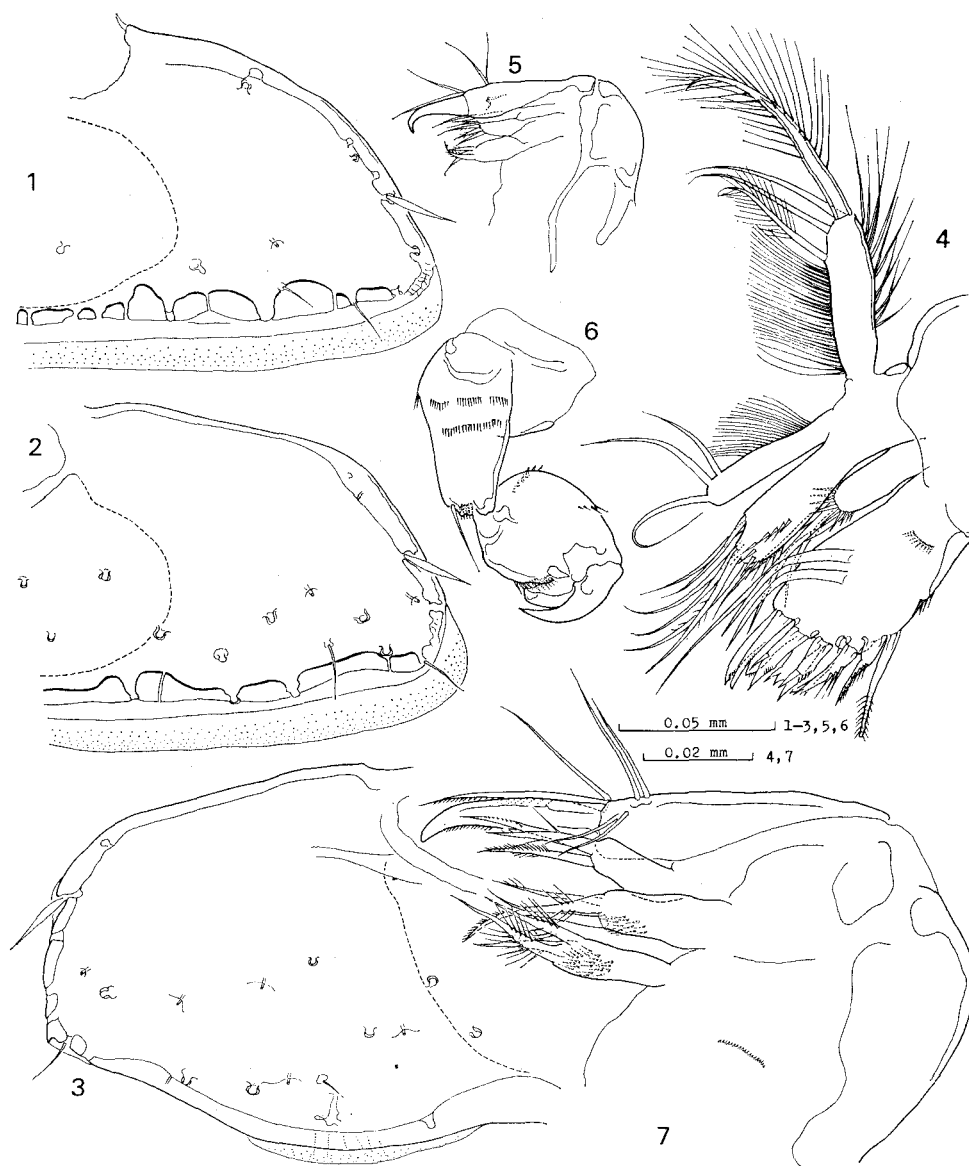


Fig. 2. *Zaus aurelii* Poppe. Female (7: a separate specimen). 1, epimeron of 1st thoracic somite; 2, ditto, 2nd thoracic somite; 3, ditto, 3rd thoracic somite; 4, maxillula; 5, maxilla; 6, maxillipede; 7, maxilla.

short setae; first two endites with some short spinules. Basis with a strong claw accompanied by one one-sided spinulose thick seta and one bare seta close to its ventral surface; two bare setae arising from posterior surface; two closely set setae, which represent rudimental endopodite, arising from ventral edge. *Maxillipede* (Fig. 2, 6). Coxa unornamented. Basis with two transverse rows (with interruption) of numerous spinules; a short seta arising from inner distal corner, accompanied by some spinules near its base. First endopodite segment oval in outline. Second endopodite segment represented by an arched strong claw.

Leg 1 (Fig. 3, 1). Intercoxal plate a little protruding midst. Praecoxa fringed with some close hairs along outer edge, and posteriorly with an accessory of a chitinous thickening with some fine spinules. Suture between coxa and basis inclined. Coxa fringed with two groups of close hairs (or hair-like spinules) along round outer margin; hairs of the proximal group shorter than those of the other one; inner rim not so

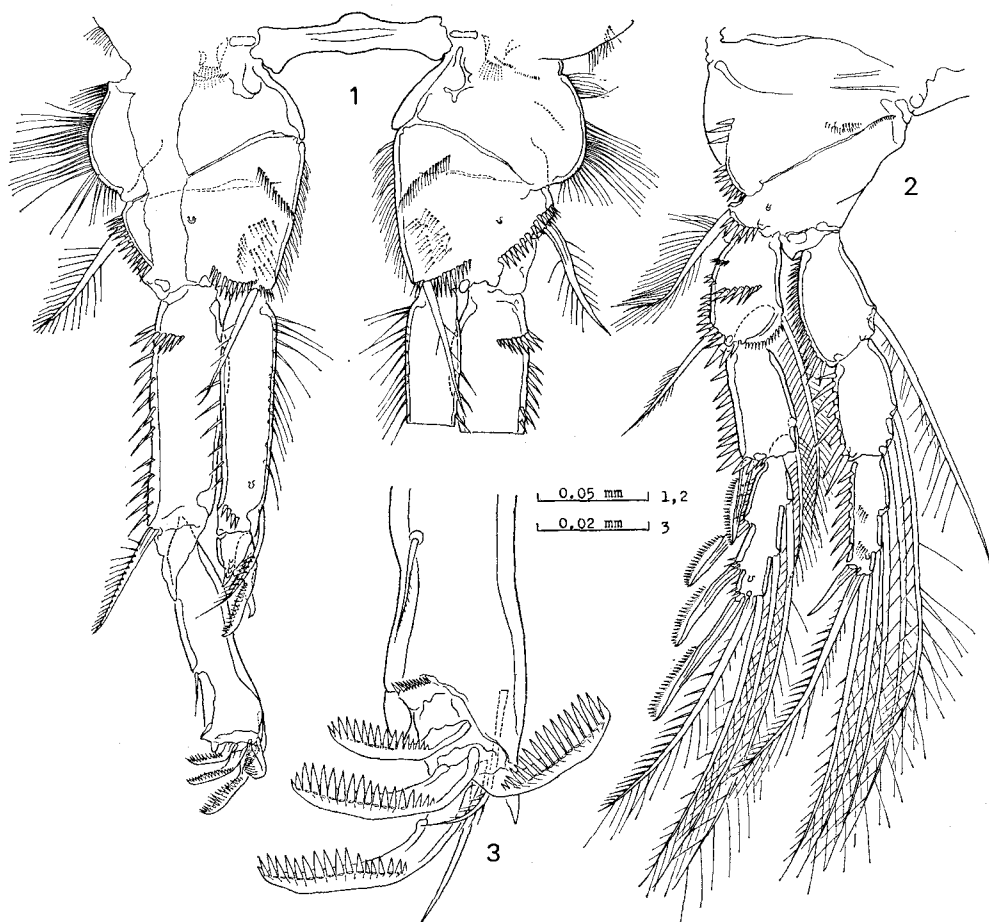


Fig. 3. *Zaus aurelii* Poppe. Female (3: a separate specimen). 1, leg 1; 2, leg 2; 3, apical part of leg 1 exopodite.

protruded, well sclerotized. Basis longer than coxa; inner rim about 1.7 times as long as coxal inner rim; distal half of outer rim represented by an articulation membrane and not sclerotized; outer seta fairly rigid, bilaterally spinulose; a row of stout spinules on anterior surface along outer margin; inner seta reaching a midway of first endopodite segment, accompanied by some spinules near base; an oblique row of more than ten narrow spinules on anterior surface near inner proximal corner; inner margin fringed with numerous hairs; some short hair-like spinules scattered on posterior surface near inner distal corner. Both rami three-segmented. First exopodite segment with no swelling on its inner edge; outer seta well-developed, with some conspicuous spinules. Second exopodite segment (see Fig. 3, 3) a little shorter than the first, ornamented with a small chitinous protuberance on outer distal end; outer seta small and with a few delicate spinules; inner seta spinulose. Third exopodite segment very short, furnished with a row of close spinules on anterior surface near proximal limit, four pectinate claws, of which membranous extension is not so developed, and one bare, rather rigid, seta on posterior distal edge. First endopodite segment somewhat narrower than first exopodite segment, with a secretory pore on anterior surface subdistally; inner seta spinulose. Second endopodite segment movable, furnished with a row of five (or more) stout spinules. Third endopodite segment terminating in one pectinate claw, one arched spine which is shorter than the pectinate claw, and a bare setula.

Leg 2 (Fig. 3, 2). Coxa with an arched row of stout spinules on anterior surface near outer margin where neither hairs nor hair-like spinules occur. Outer seta of basis thick, with numerous soft hairs. First exopodite segment with a secretory pore on anterior surface near outer distal corner and a serrate hyaline membrane (see Pl. I, fig. 2). Middle endopodite segment with two inner setae bearing three rows of hairs. Other spinal and setal ornamentation as in the figure. *Leg 3* (Fig. 4, 1-2). Outer edge of coxa fringed with some short spinules (without hair). Outer seta of basis bare and a little extending beyond first exopodite segment. *Leg 4* (Fig. 4, 3). Demarcation between coxa and basis markedly inclined. Outer seta of basis bare, not extending beyond first exopodite segment. *Leg 5* (Fig. 5, 1-2). Baseoendopodite about 1.6 times as wide as long; outer edge of inner expansion almost vertically stretched, occupying three-fifths of the length of this segment, entirely bare; inner two of the four marginal setae almost as long as outer edge of inner expansion, with little flexibility, and with very delicate spinules bilaterally; third marginal seta longest, about five times as long as previous ones, with some very short spinules; fourth (outermost) one somewhat shorter than the third, much longer than exopodite segment, with short spinules (with no long hair); chitinous ridges among the first three setae markedly sclerotized and extending proximally; outer seta arising from a long cylindrical process, entirely bare; some spinules, which are roughly arranged transversely, occurring on anterior surface; space between the first two setae wider than the next, with no spinule; a few narrow spinules arising from posterior surface of chitinous ridge between the second and third setae; four secretory pores occurring on anterior surface as shown in the figure. Exopodite about 2.3 times as long as greatest width, not oval in outline, furnished with five setae in all; first seta arising from a ledge located at an inner subdistal edge, shorter than this segment, rather stout, with no hairs but numerous delicate

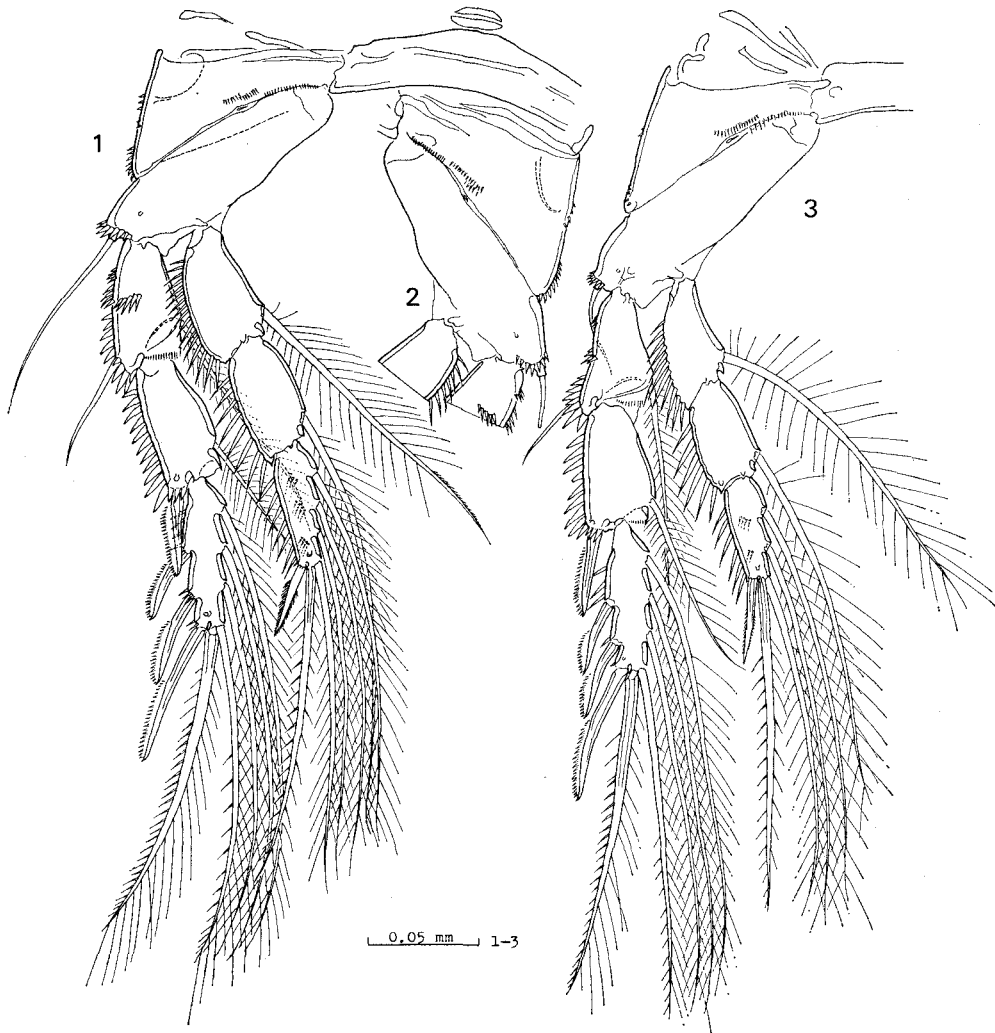


Fig. 4. *Zaus aurelii* Poppe. Female. 1, leg 3; 2, coxa and basis of left leg 3; 3, leg 4.

spinules; second (terminal) seta thickening basally, a little longer than this segment, with few, widely spaced, very delicate spinules; third seta located just opposite to the first one, short, rather spiniform, and with some spaced spinules; fourth one almost as long as the third, slender and bare; fifth one much longer than this segment, entirely bare; inner edge fringed with some sharp spinules; numerous well-developed spinules occurring on both anterior and posterior surfaces near outer margin and also along outer margin.

Male. Body (Fig. 6, 1) 0.61 mm long. Rostrum (Fig. 6, 4) somewhat visible in dorsal aspect. Brown tinge of third thoracic somite obscure. Epimeral spine-like sensillae (Fig. 6, 2) of first three thoracic somites well-developed as in the female



Fig. 5. *Zaus aurelii* Poppe. Female (3: a separate specimen). 1, right leg 5; 2, left leg 5; 3, left leg 5.

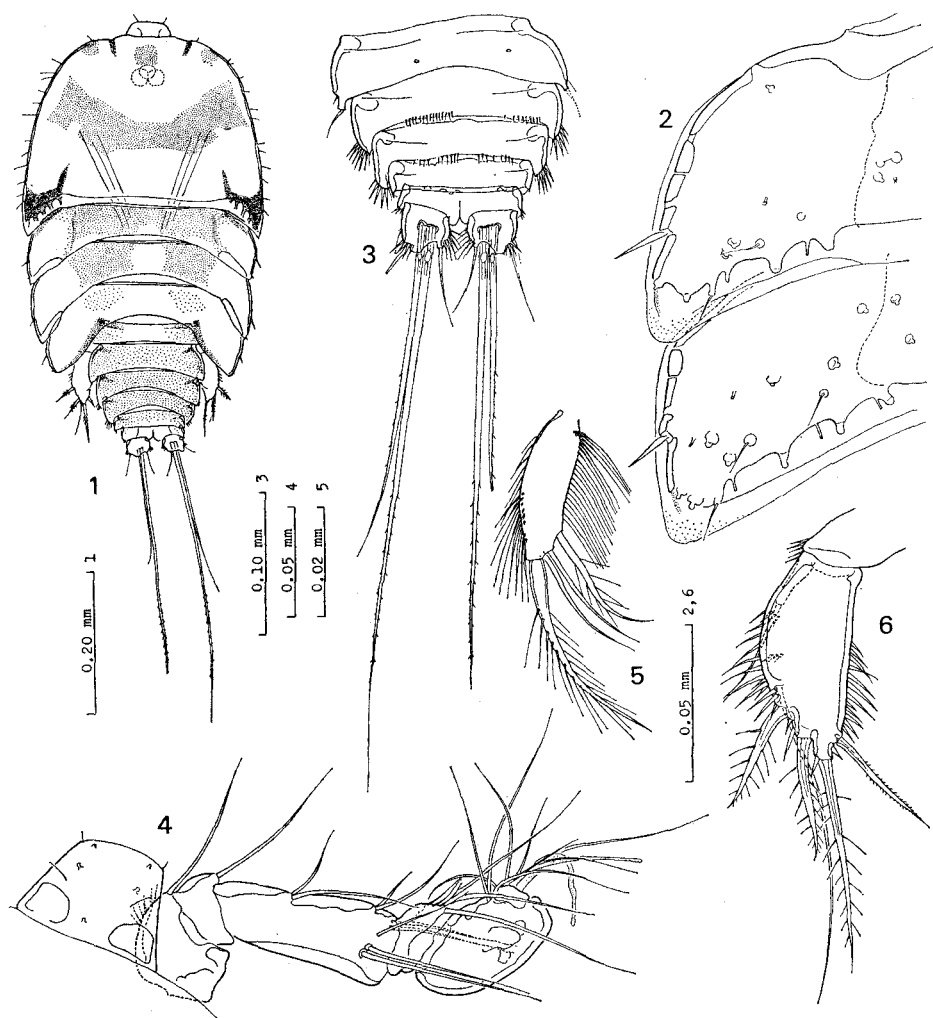


Fig. 6. *Zaus aurelii* Poppe. Male. 1, habitus, dorsal; 2, epimera of first two thoracic somites; 3, abdomen, ventral; 4, rostrum and antennule; 5, maxillular exopodite; 6, leg 5.

described. Second and third abdominal somites each with some spinules on ventral surface near posterior margin (Fig. 6, 3). Antennule (Fig. 6, 4) subchirocer. Antenna and oral appendages ornamented as in the female. Maxillular exopodite as shown in Fig. 6, 5.

Leg 1-leg 4 as in the female. Leg 5 (Fig. 6, 6). Baseoendopodite small; outer seta arising from a cylindrical process. Exopodite a little longer than twice as long as wide, with five setae in all; first (inner) seta shorter than this segment, located subdistally, with numerous very delicate spinules; second (terminal) seta almost as long as this segment, thick, and with some spaced remarkable spinules bilaterally; third and fourth setae subequal in length, almost as long as the first one, with some spaced

spinules as in the terminal one; fifth seta more than 1.5 times as long as this segment, slender and bare; inner and outer edges spinulose. Leg 6 (Fig. 6, 3) represented by a setula arising from a short cylindrical process.

Variability. Four females and two males, excluding the pair described, were dissected. Body length seems to be highly variable. The length is 0.80 mm, 0.81 mm (some of the figures of mouth parts and leg 1 were based on this specimen), 0.85 mm and 0.95 mm in the females, 0.60 mm and 0.56 mm in the males. Among these specimens, the brown tinge of the largest female is darker than in the others. The left one of the fifth pair of legs of this specimen is shown in Fig. 5, 3. The number of spinules on the anterior surface of baseoendopodite of female leg 5 varies among individuals and even between both rami in a single individual.

Remarks. The present specimens examined accord well with the description and figures of *Z. aurelii* reported by Poppe (1884) from the northern North Pacific, especially in the large size, appearance of broad body, ornamentation of leg 1 and, further, the shape as well as the setal armature of leg 5 in both sexes. Many important characters of this species can be easily found in Poppe's excellent figures. In the baseoendopodite of the female leg 5, the outer rim of the inner expansion is almost vertically stretched, bare, and occupies more than one-third of the length; moreover, the chitinous ridge between the first two marginal setae is naked and markedly extends proximally, and the next ridge, between the second and third setae, bears some spinules. The lengths of these setae on the inner expansion are also similar to those of the present material. The fairly elongate appearance of the exopodite segment is well demonstrated in Poppe's figure. The male leg 5 has three thick setae which are furnished with some spaced spinules. The present specimens of Alaska accord completely with Poppe's material even in such a character of the male so far disregarded. In Poppe's figure of the female leg 5, no spinular row on the anterior surface of baseoendopodite is illustrated. It does not mean an essential difference between his material and the present one because the number of spinules occasionally reduces in the present one too.

Although the synonymy and previous records of this species is discussed by Lang (1965), an additional comment on some related species is necessary. *Z. aurelii* sensu T. & A. Scott (1901) is not the species, as pointed out by Lang (op. cit.). On the other hand, *Z. aurelii* sensu Willey (1923, fig. 20) is similar to *Z. intermedius* Nicholls rather than to *Z. aurelii* because his illustration of the female leg 5 shows some of the distinctive characters of *Z. intermedius*; namely, in the baseoendopodite, the outer rim somewhat arched and inclined, and spinulose; the space between the second and third marginal setae wider than that between the first and second setae; the fourth marginal seta markedly shorter than the third seta. These characters of the female leg 5 are found in *Z. caeruleus* Campbell, 1929 from Vancouver Island too. *Z. serratus* Monk, 1941 from California resembles *Z. aurelii* in the female leg 5 as well as the coloration of body, but it differs markedly from the latter in the proportion of the coxa and basis of the leg 1. It, therefore, can be concluded that there has been neither reliable record nor synonym of *Z. aurelii* since the publication by Poppe in 1884.

For the time being, incidentally, it is rather difficult to refer *Z. caeruleus* and

Z. serratus to *Z. intermedius* because both are discernible from the latter by the shape of the basis of leg 1 or the ornamentation of the last endopodite segment of leg 1.

Specimens examined. Five females and three males (4-VII-1976; Hirano leg.). Some undissected specimens of both sexes are preserved for a further study.

Zaus robustus Itô

(Figs. 7-9)

Zaus robustus Itô, 1974, p. 555, figs. 4-7.

At a glance, I noticed that a *Zaus*-species of compact body was dominant in the present sample. The females of this species which were tintured with pale greenish brown or pale green on almost whole of the body were easily discernible from some large individuals which were tintured with orange on the whole body or green on several somites. Despite of marked difference in the size and coloration, no essential difference in the ornamentation of appendages has been found among the dissected specimens of these different 'forms'. Their appendages are almost identical with those of *Z. robustus* which has been described from Hokkaido, northern Japan, by Itô (1974). The first exopodite segment of their leg 1 (see Pl. I, fig. 4) has a remarkable swelling which is one of the most prominent characters of *Z. robustus*, and the peculiar shape of the baseoendopodite of leg 5 is also a characteristic of the species. As far as regarding the characters in the appendages, I don't hesitate to refer them to *Z. robustus*. Their coloration, however, is a problem for the identification because no example of the same coloration has so far been found in the specimens of Hokkaido. I have examined several formalin-preserved samples collected at Akkeshi, Hokkaido, and have found 17 females and six males. Coloration of one of the females found is identical with that of the specimen previously reported (Itô, 1974, fig. 7, 7). In the other females the U-shaped brown area on the cephalothoracic somite is obscure, and almost whole of the body is tintured with bluish purple. The males are tintured with pale bluish purple. Several specimens of both sexes are of obscure brown tinge on dorsal surface of either thorax or abdomen, especially on the chitinous rim. As far as can be seen in those specimens, no individual is identical with either one of the specimens of Alaska in the coloration. Although I suppose these Alaskan forms should be distinguished from Japanese ones at least as a separate subspecies, I postpone to decide it since I am going to carry out a thorough investigation of an enough material. In the following, some comments on the morphology are given, and some errors in the previous paper are corrected.

As briefly mentioned, the present material of *Z. robustus* is divisible into two size categories, namely, small form (abbr. S) and large form (L); moreover, in the latter, two different forms of coloration are recognized, the one is tintured with orange on almost whole of the body (O), and the other (G) is characterized by green tinge on several somites. No orange male was found.

Female of S-form. The specimen illustrated (Fig. 7, 1) is 0.69 mm long, tintured with pale green. Other two dissected specimens are 0.72 mm and 0.69 mm long.

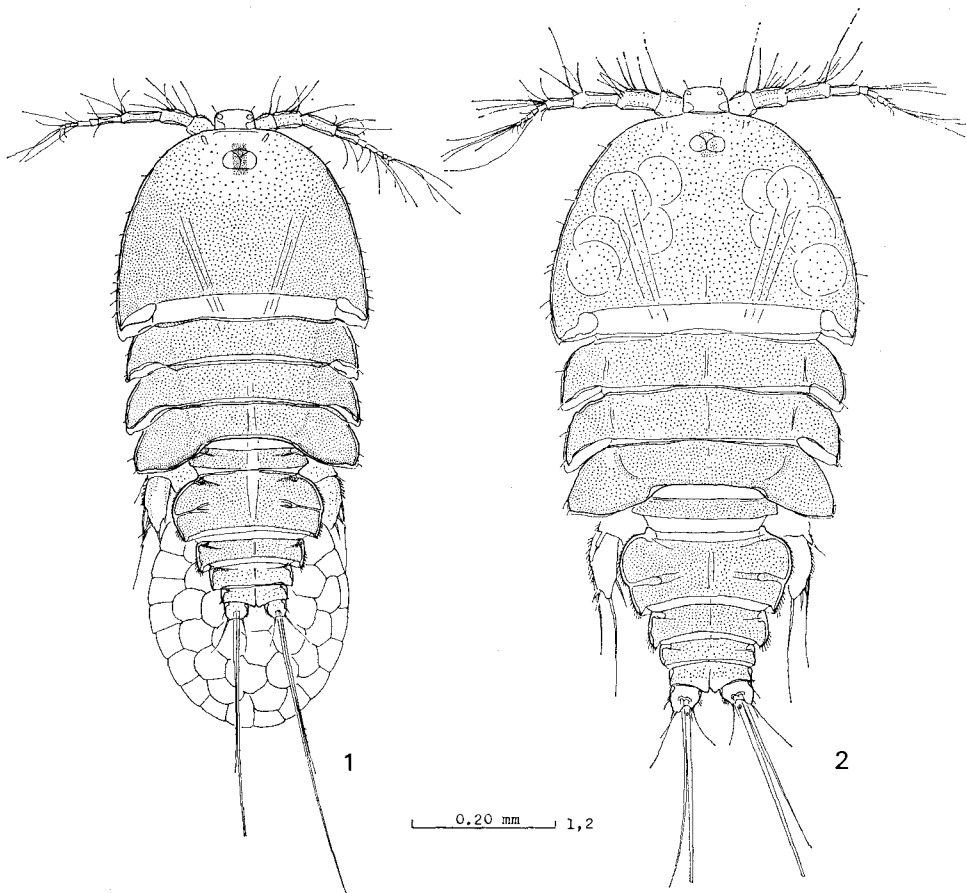


Fig. 7. *Zaus robustus* Itô. 1, ovigerous female of S-form; 2, female of LO-form.

These three specimens as well as other numerous undissected ones of S-form have a purple patch above the nauplius eye.

Male of S-form. The specimen illustrated (Fig. 8, 3) is 0.50 mm long, and pairs with a fifth copepodid female. Other two dissected ones are 0.51 mm and 0.50 mm long. Their coloration is more faint than in the females.

Female of LO-form. The specimen illustrated (Fig. 7, 2) is 0.85 mm long, and apparently pregnant. Almost whole of the body is tintured with orange. Several proximal segments of the antennule are light blue or bluish green. A blue patch is present above the nauplius eye. A specimen undissected is almost the same in the coloration as well as the body length.

Female of LG-form. The specimen illustrated (Fig. 8, 1) is 0.81 mm long, ovigerous. The third and fourth thoracic somites as well as the genital double-somite are tintured with deep green. The fifth leg of this specimen is shown in Fig. 9, 4.

Male of LG-form. The specimen illustrated (Fig. 8, 2) is 0.58 mm long and pairs with a fourth copepodid female. Green color of tergal area of the third thoracic somite

is obscure. The fifth leg of this specimen is shown in Fig. 9, 6. A separate specimen dissected is 0.56 mm long.

All the specimens dissected have a spinulose accessory on the posterior surface of praecoxa of leg 1 (see Fig. 9, 2). This accessory is also present in the specimens previously reported from Hokkaido. Distal half of the outer rim of basis of the leg 1 is membranous. This membranous part seems to be shrunk when the exopodite is leaned laterally. The leg previously illustrated (Itô, 1974, fig. 5, 7) represents such a condition; therefore, the statement that the outer seta of coxa arises from the middle of the outer edge is incorrect. A setula attaches onto a point near the base of the geniculate spine of the last endopodite segment of leg 1.

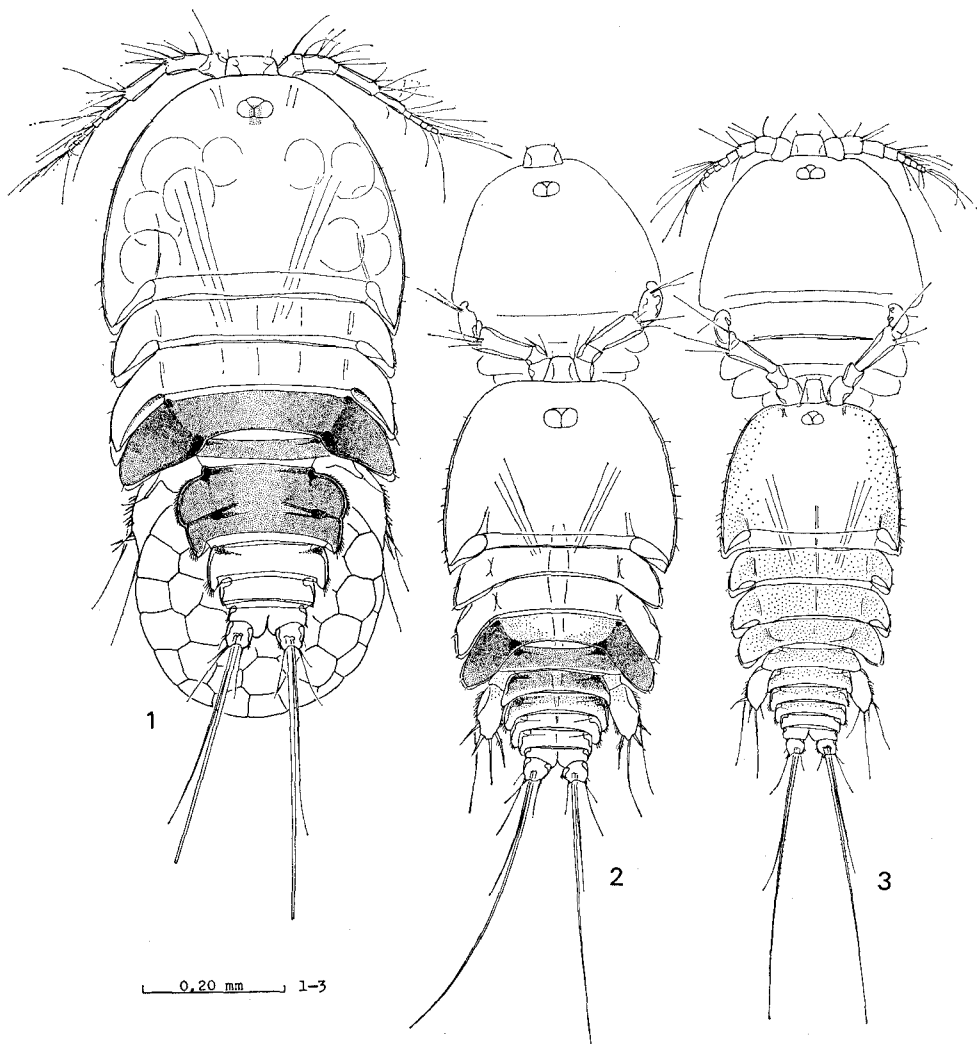


Fig. 8. *Zaus robustus* Itô. 1, ovigerous female of LG-form; 2, male of LG-form pairing with a fourth copepodid female; 3, male of S-form pairing with a fifth copepodid female.

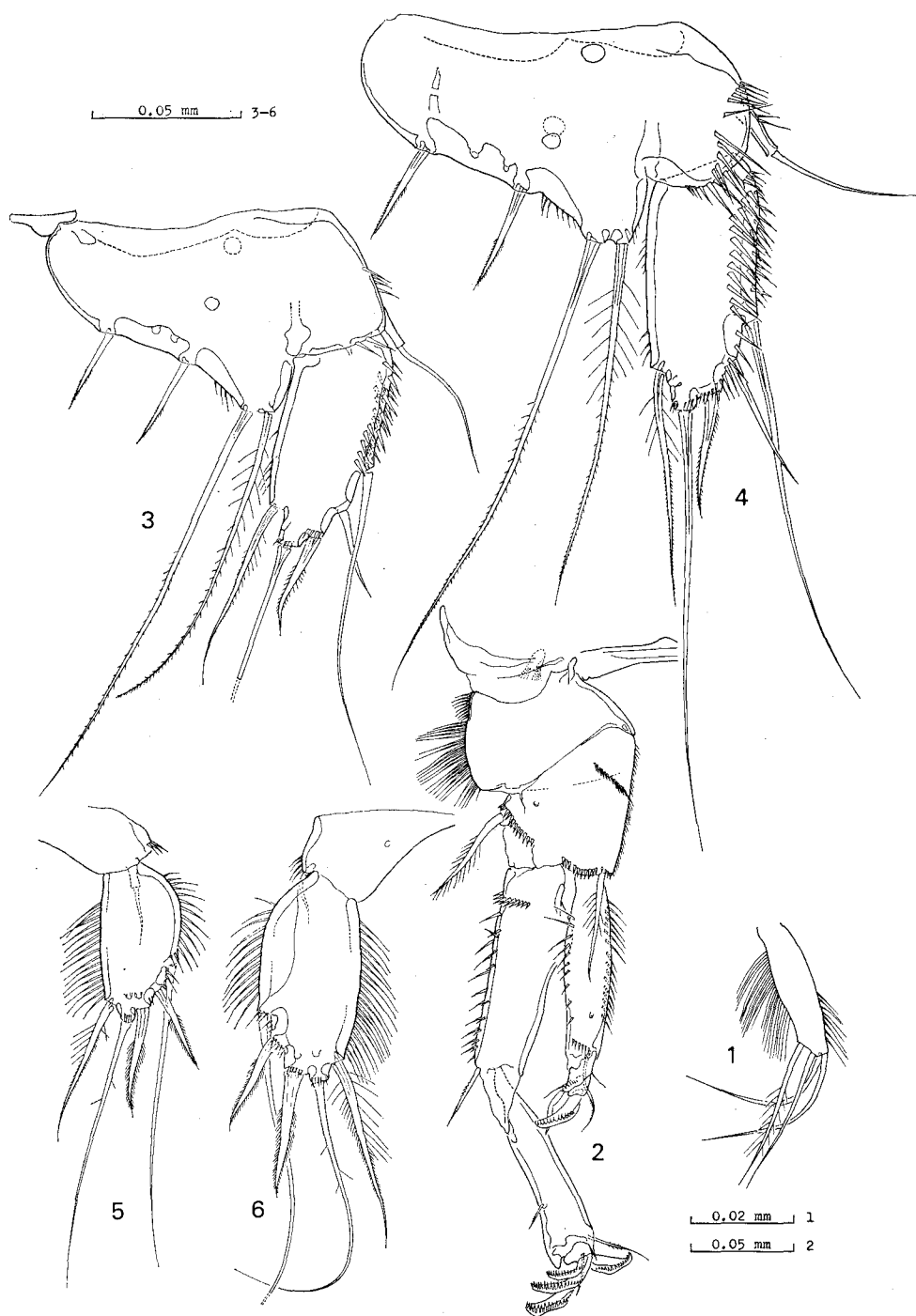


Fig. 9. *Zaus robustus* Itô. 1, maxillular exopodite of S-form ♀; 2, leg 1 of S-form ♀; 3, leg 5 of S-form ♀; 4, leg 5 of LO-form ♀; 5, leg 5 of S-form ♂; 6, leg 5 of LG-form ♂

In the female leg 5, the inner seta of the exopodite bears some long hairs on its proximal third or half (also in the specimens of Hokkaido) and is situated a little more distally than in the specimens of Hokkaido. In the female of S-form 0.72 mm long, the terminal seta of the exopodite of the left leg 5 bears very few, short spinules which are widely spaced. No such spinules are found on the corresponding seta of the other females dissected. Although the space between the second and third setae of the baseoendopodite segment is usually furnished with some spinules, an aberrant example is found in the S-form female 0.69 mm long whose right leg has no spinule on the edge in question. The number of spinules on the outer side of baseoendopodite is fairly variable even between both legs of a single individual.

In both sexes, the outer seta of the basis of leg 3 is long and extends far beyond the first exopodite segment (in the specimens of Hokkaido as well; cf. Itô, 1976, fig. 8, 4).

In the males, the terminal seta of the exopodite of leg 5 occasionally bears few, very delicate hairs as shown in the figures (Fig. 9, 5-6) (such the characteristic is found in several specimens of Hokkaido too).

Remarks. The characteristic that the inner seta of the exopodite of leg 5 in the females is situated more distally than in the specimens of Hokkaido is a very trifling difference, though it cannot be entirely disregarded. While, as already mentioned, the taxonomic solution for the difference in the coloration between the materials from Hokkaido and Alaska is postponed, this difference in the setal situation of the leg 5 must be of certain importance if they are separated from each other as any taxonomic categories. Incidentally, the specimens so far found in Hokkaido correspond with the small form of the Alaskan material in the size.

Specimens examined. Three females of S-form, three males of S-form, one female of LO-form, one female of LG-form, and two males of LG-form were dissected.

One female of the fourth copepodid and one female of the fifth copepodid were also dissected.

Numerous specimens of S-form (♀♀ and ♂♂), one female of LO-form, and one female and two males of LG-form are preserved without dissection.

Zaus hiranoi n. sp.

(Figs. 10-15)

Female (Holotype). Body (Fig. 10, 1) 0.70 mm long, rostrum and furcal setae excluded, and 0.36 mm wide, tintured with light blue, except for a small area of hind dorsal surface of cephalothorax where is with brown tinge; a blue spot just above nauplius eye; dorsal surface of most somites with scale-like thickenings which are transversely arranged (see Fig. 10, 2-4). Rostrum (Fig. 11, 1) almost horizontally situated, with two pairs of fine sensillae. Cephalothorax longer than succeeding three thoracic somites combined. Epimeral sensillae of thoracic somites (Fig. 10, 2-3) represented by fine hairs. Genital double-somite (Fig. 10, 4-5) subdivided by a circumambient chitinous suture; three setulae occurring on both lateral limits of genital area; ventral hind edge with no spinule. Furcal ramus a little shorter than wide. *Antennule* (Fig. 11, 1) nine-segmented; sixth segment a little longer than fifth

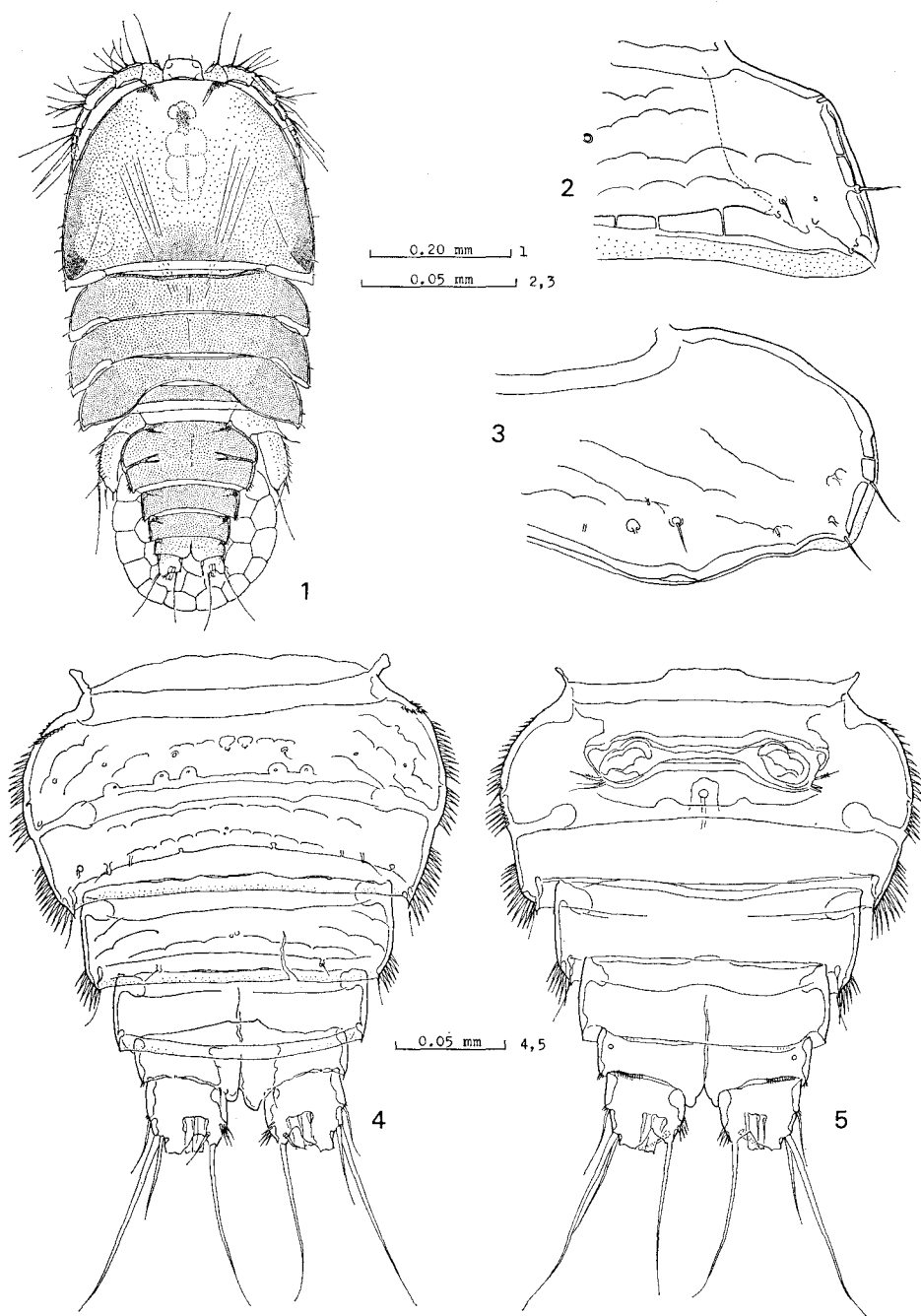


Fig 10. *Zaus hiranoi* n. sp. Female (Holotype). 1, habitus, dorsal; 2, epimeron of 1st thoracic somite; 3, ditto, 3rd thoracic somite; 4, abdomen, dorsal; 5, ditto, ventral.

one. *Antenna* (Fig. 11, 2). Second exopodite segment with two terminal setae, the narrower one bare and almost as long as two exopodite segments combined (Fig. 11, 3). Other setal and spinal characters as in *Z. aurelii*. *Mandible* (Fig. 11, 4). Praecoxa ornamented with a row of numerous spinules near base of coxa-basis. Coxa-basis

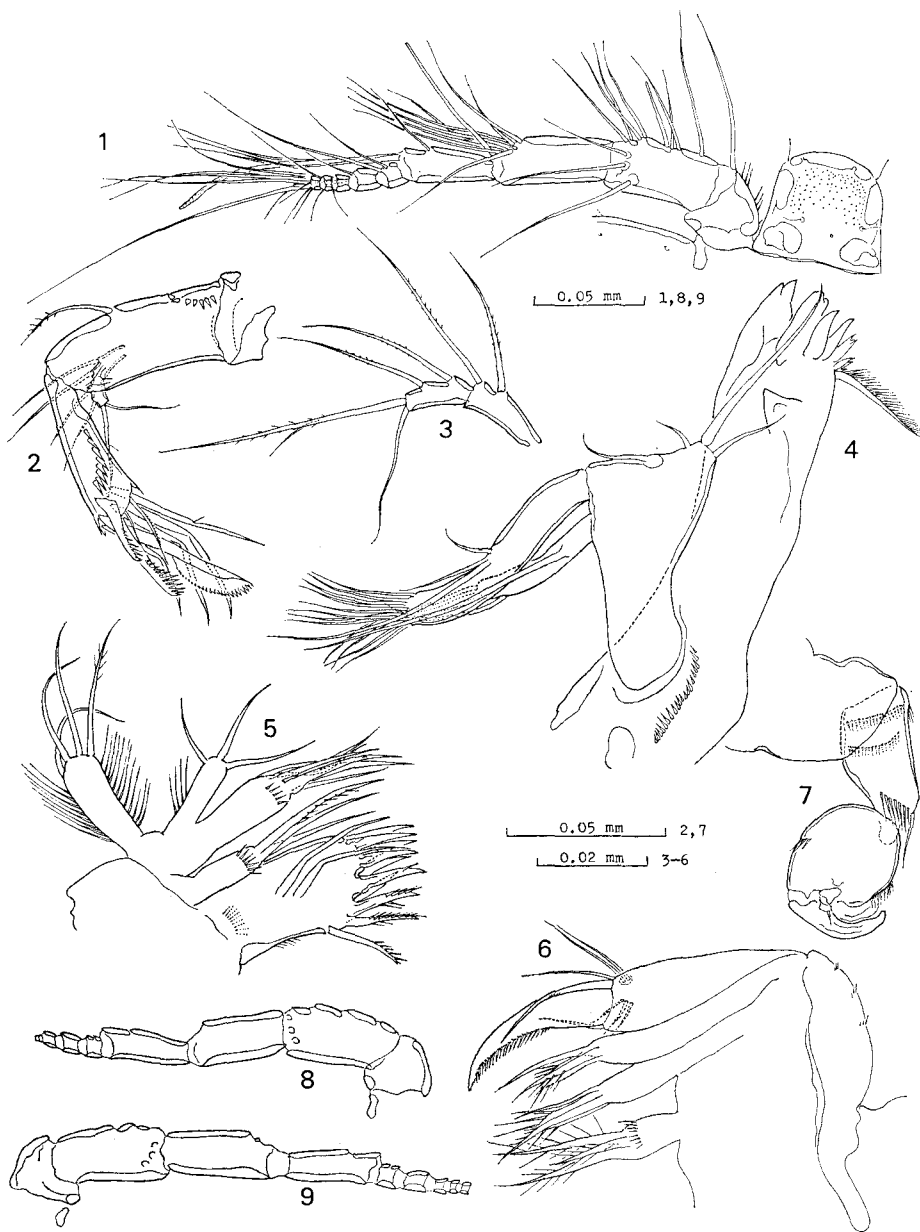


Fig. 11. *Zaus hiranoi* n. sp. Female (1-7, holotype; 8, 9, a paratypic specimen). 1, rostrum and antennule; 2, antenna; 3, exopodite of left antenna; 4, mandible; 5, maxillula; 6, maxilla; 7, maxillipede; 8, aberrant left antennule; 9, normal right antennule.

widening distally, with two setae on inner distal corner, of which the longer one is about as long as this segment; two short setae on distal edge, one of which is located near inner corner and the other arises from the middle. Endopodite represented by an elongate segment, about as long as coxa-basis, with three setae on the middle of inner (ventral) edge and eight (?) narrow setae on distal or subdistal edge. Exopodite shorter than endopodite, furnished with a long seta arising from a point at basal one-third of the length, one seta on subdistal outer (dorsal) edge and four (?) narrow setae on distal end. *Maxillula* (Fig. 11, 5). Arthrite of praecoxa ornamented with eight claws on inner edge and two spinulose short setae on dorsal edge; two parallel setae arising from anterior surface; an arched row of fine spinules on posterior surface near outer limit. Coxal process reaching the middle of arthrite of praecoxa, terminating in one spinulose and two bare setae; some spinules occurring subapically. Basal process, with three bare setae apically; a few hairs on ventral rim. Exopodite thicker than endopodite segment, furnished with four setae of an equal length, of which the innermost one is hairy; some hairs or hair-like spinules along both rims. *Maxilla* (Fig. 11, 6). Syncoxa with three endites. First endite with three sparsely spinulose setae and a spinular row. Second and third endites each with one bare and two spinulose setae, of which the shorter one is much thickened. Basis ornamented with a very strong claw accompanied by a narrow seta on its dorsal limit, and one spinulose (geniculate?) seta and one narrow seta on ventral limit; two close bare setae on ventral surface; three close setulae occurring posteriorly. *Maxillipede* (Fig. 11, 7). Coxa bare and rather membranous. Basis almost as long as coxa, with two transverse rows of numerous fine spinules, and one short seta accompanied by some spinules near base. First endopodite segment well swelling.

Leg I (Fig. 12, 1). Free edge of intercoxal plate scarcely swelling out at the middle. Praecoxa with a chitinous accessory thickening with some fine spinules on its posterior surface; outer margin entirely bare. Coxa a little wider than long; inner margin not so rounded; outer margin furnished with a few spinules subproximally and some (13 in the illustrated leg) elongate spinules along its distal half; a transverse row of numerous delicate spinules on anterior surface near proximal limit; an arched row of spinules occurring near distal limit of anterior surface. Basis almost as long as coxa (measured at the middle), scarcely tapering distally; inner margin spinulose; some short hairs occurring on posterior surface near inner distal corner; outer seta arising from a point at proximal one-third of the length; inner seta reaching the middle of first endopodite segment. Both rami three-segmented. First exopodite segment with no swelling on its inner side; outer seta finely spinulose. Second exopodite segment a little shorter than the first, furnished with a bare (?) setula on a point at about two-thirds of the length of outer edge and one short hairy seta on a subdistal inner edge. Third exopodite segment ornamented with four serrate claws and a bare setula; a short row of a few delicate spinules near basal limit of anterior surface. Endopodite; first segment narrower and shorter than the first exopodite segment, with one hairy inner seta, a transverse row of a few spinules near distal limit of anterior surface; second segment (Fig. 12, 3) with an oblique row of spinules on anterior surface, and with a

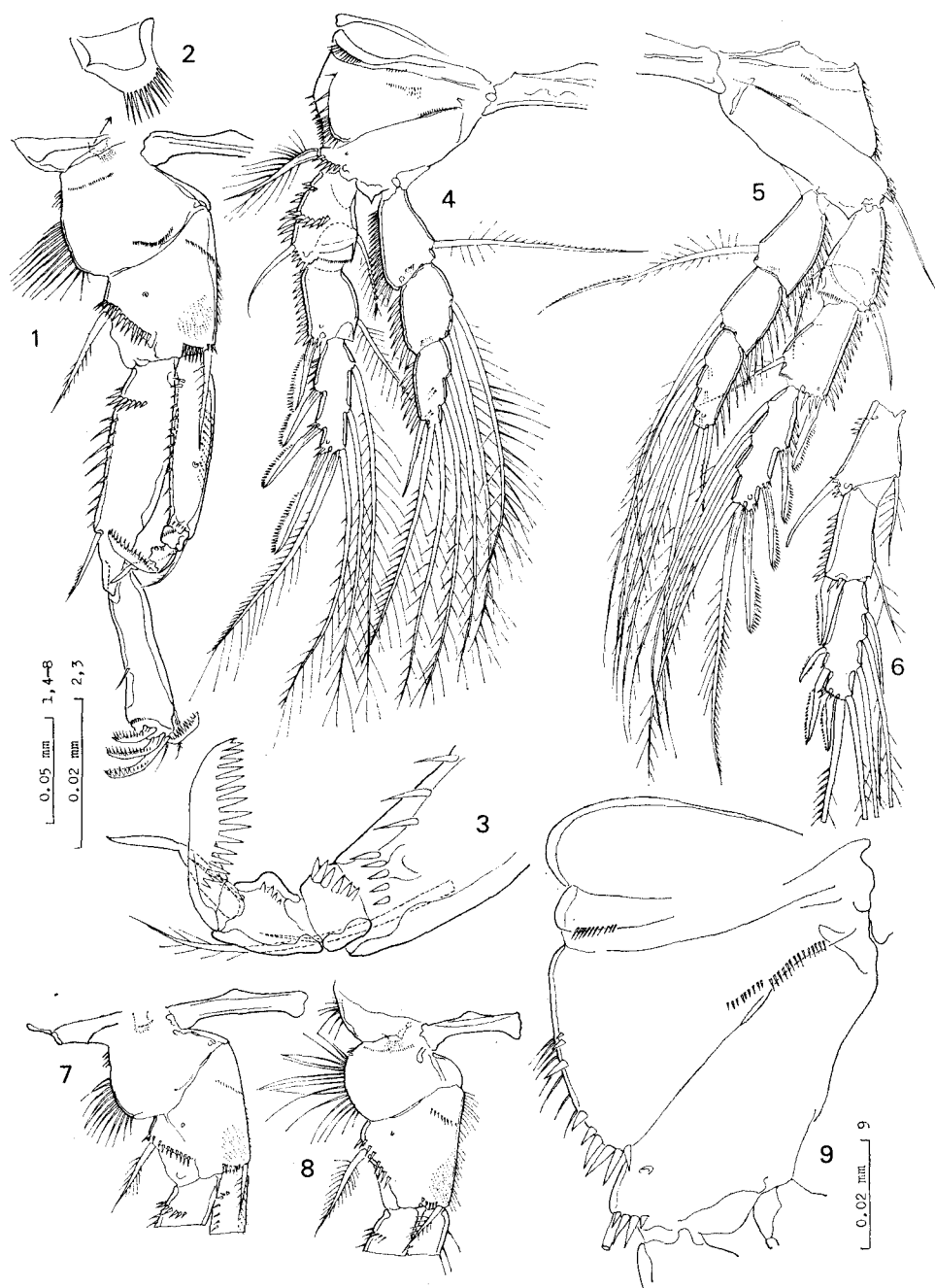


Fig. 12. *Zaus hiranoi* n. sp. Female (holotype). 1, leg 1; 2, praecoxal accessory of leg 1; 3, apical part of leg 1 endopodite; 4, leg 2; 5, leg 3; 6, aberrant exopodite of right leg 3. Male (allotype). 7, basal part of leg 1. *Zaus intermedius* Nicholls. A male collected from Oshoro, Hokkaido. 8, basal part of leg 1; 9, basal part of leg 2.

bare setula on inner distal corner; third segment longer than the second, furnished with one serrate claw, one geniculate spine and one bare setula (spine?) on distal end, and with a few spinules on anterior surface near outer edge. *Leg 2* (Fig. 12, 4). Praecoxa with some fine spinules along anterodistal edge. Two vertical rows of spinules (not hair-like) on or near outer margin. Outer seta of basis thick and with long hairs. Setal and spinal ornamentation of both rami as shown in the figure. Hyaline membrane on distal edge of first exopodite segment finely serrate. Two inner setae of second endopodite segment furnished with three rows of hairs. Last endopodite segment shorter than 2.5 times as long as wide. *Leg 3* (Fig. 12, 5). Outer seta of basis narrow and bare, not extending beyond distal end of first exopodite segment. Setal and spinal ornamentation of both rami as shown in the figure. Outer spines of the exopodite of the right leg (Fig. 12, 6) are somewhat aberrant, and the first segment is lacking in a serrate hyaline membrane. *Leg 4* (Fig. 13, 1). Outer seta of basis much elongated, extending far beyond distal end of second exopodite segment. Setal and spinal ornamentation of both rami as shown in the figure. *Leg 5* (Fig. 13, 2). Baseoendopodite with a transverse (somewhat arched) row of fine spinules on its central area of anterior surface; outer rim of inner expansion occupying about a quarter of the length of this segment, a little inclined and bare; all marginal setae of inner expansion flexible and with delicate spinules; second seta a little longer than the first; third seta longest, about twice as long as exopodite segment; fourth one somewhat longer than exopodite segment; space between the first two setae bare and almost as long as the next where some spinules occur; outer seta arising from a short cylindrical process. Exopodite more than twice as long as wide; first (innermost) seta with numerous delicate spinules (no hair), arising from a ledge located at about seven-ninths of the length of inner margin, almost as long as this segment; second (terminal) seta about 1.5 times as long as this segment, with some spaced spinules; third seta short and thick, densely furnished with numerous fine spinules; fourth seta as long as the third, with no spinule; fifth seta elongate, about as long as the second, entirely bare; some spinules on inner margin; a number of spinules occurring along outer margin and on posterior surface near outer margin.

Male (Allotype). Body (Fig. 14, 1) 0.51 mm long, tintured with blue. Cephalothorax wider than long. Second and third abdominal somites (Fig. 14, 2) each with a transverse row of spinules on ventral surface. Ornamentation of furcal ramus as in the female. *Antennule* (Fig. 14, 3) subchilocer. *Antenna* and *oral appendages* as in the female.

Leg 1 (Figs. 12, 7, 14, 4). Transverse spinular row near basal limit of anterior surface of coxa shorter than that in the female. Proportion and principal ornamentation of praecoxa, coxa, basis, and both rami almost as in the female. *Leg 2-leg 4*. Ornamentation as in the female. Outer seta of basis of leg 4 (Fig. 13, 4) extending far beyond its second exopodite segment. *Leg 5* (Fig. 14, 5). A short row of spinules occurring on anterior (ventral) surface of baseoendopodite. Exopodite elongate oval in outline, a little longer than twice as long as wide; first (innermost) seta arising a ledge located at a subapical inner edge, almost as long as this segment, flexible and

with minute spinules; second (terminal) seta much longer than this segment, with some spaced conspicuous spinules; third and fourth setae subequal in length, stout and densely spinulose; fifth seta arising from a point at two-thirds of the length of outer edge, muchelongate and entirely bare; inner edge fringed with some narrow long

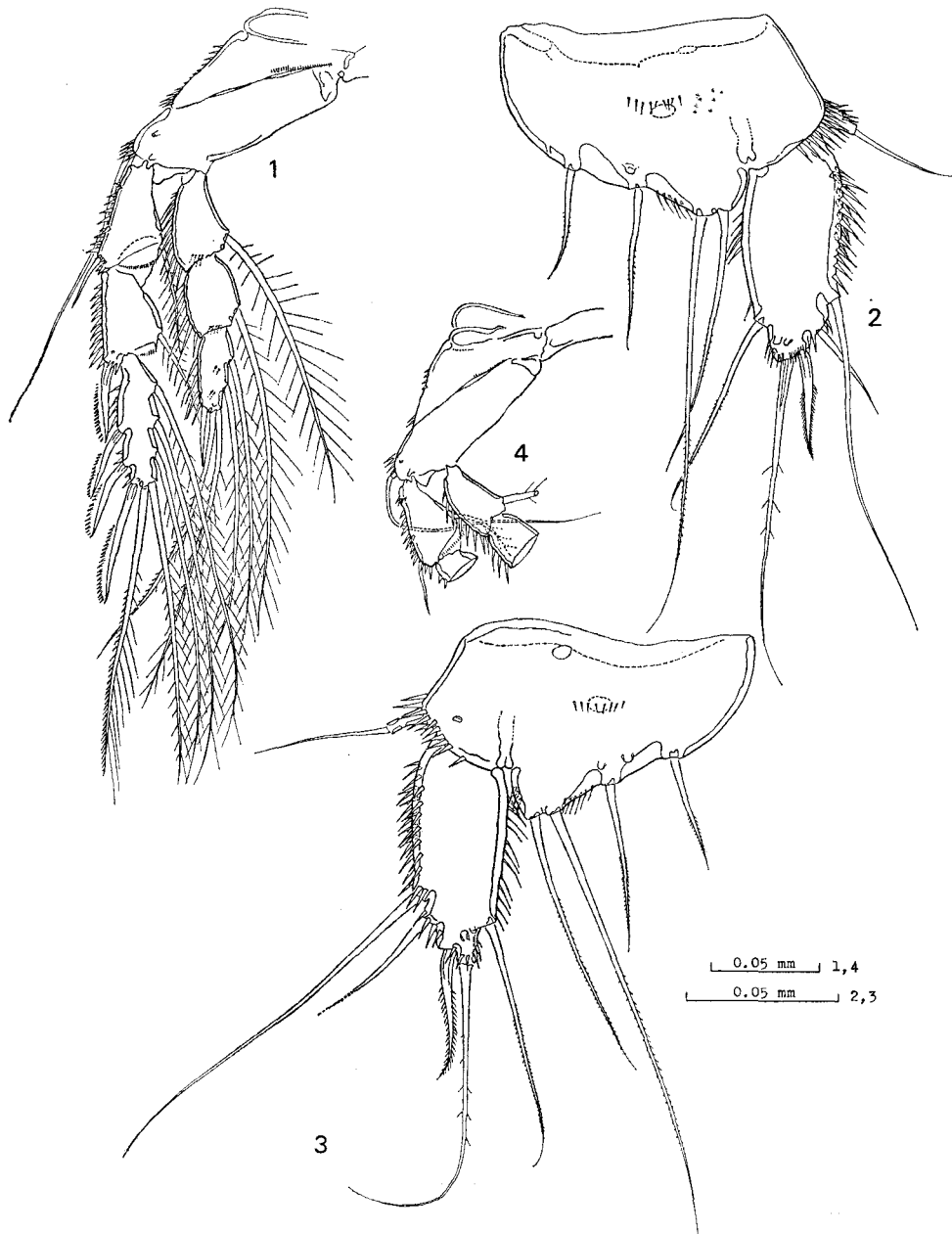


Fig. 13. *Zaus hiranoi* n. sp. Female (1, 2, holotype; 3, a paratypic specimen). 1, leg 4; 2, leg 5; 3, ditto. Male (allotype). 4, basal part of leg 4, showing elongate outer seta of basis.

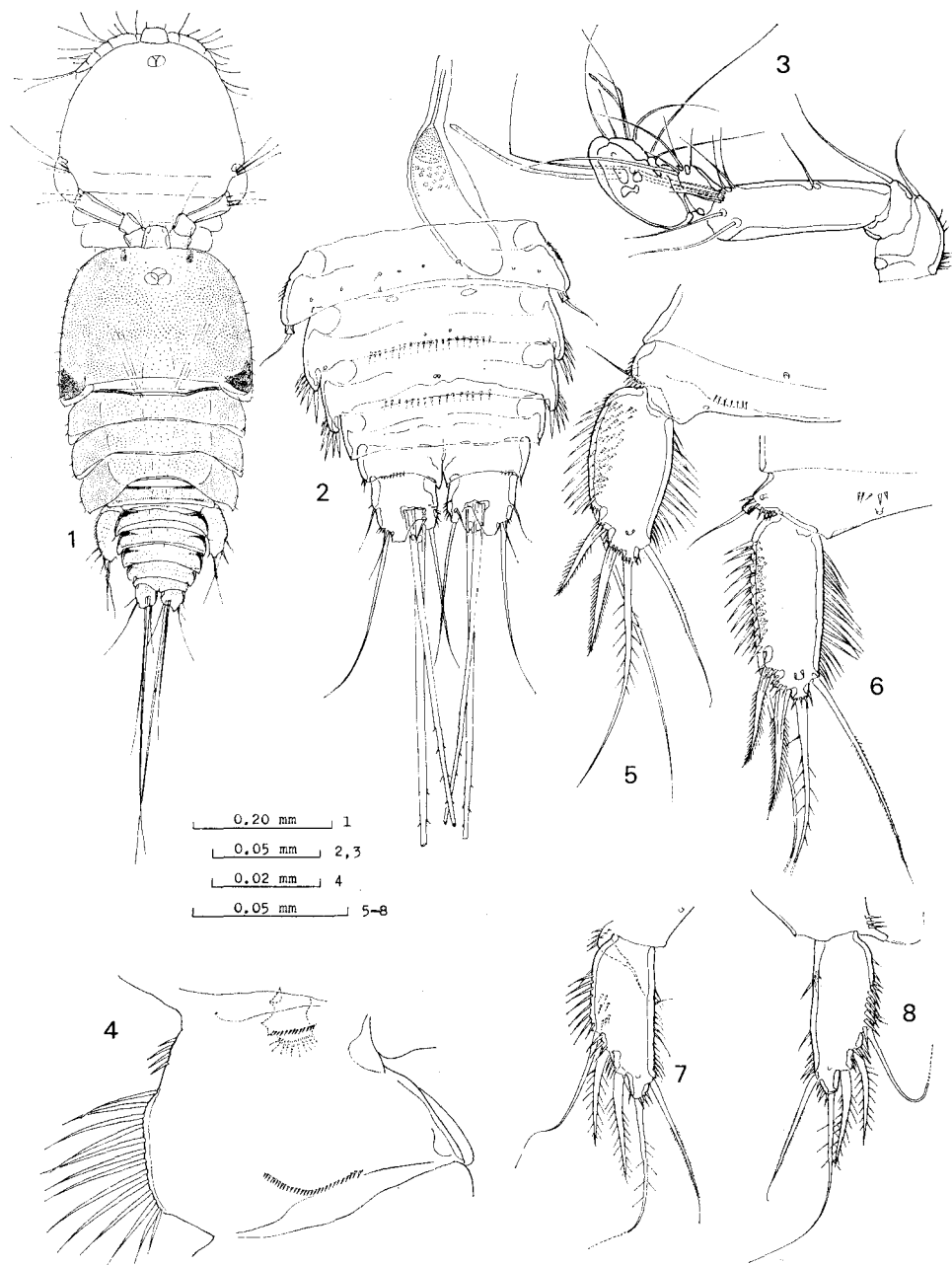


Fig. 14. *Zaus hiranai* n. sp. Male (1-5, allotype; 6, a paratypic specimen). 1, habitus, dorsal, pairing with a fourth copepodid female; 2, abdomen, dorsal; 3, antennule; 4, praecoxa and coxa of leg 1; 5, leg 5; 6, ditto. *Zaus intermedius* Nicholls. A male collected from Oshoro, Hokkaido. 7, right leg 5; 8, left leg 5.

spinules; a number of spinules along outer margin and on posterior surface near outer margin. Leg 6 (Fig. 14, 2) represented by a bare setula arising from a short cylindrical process.

Variability and abnormality. Three adult females and two adult males, excluding the holotype as well as the allotype, were dissected. Each body length is as follows: 0.67 mm, 0.62 mm, and 0.70 mm in the females; 0.56 mm, and 0.48 mm in the males. In the female 0.67 mm long, the left antennule is aberrant, though the right one is normal (cf. Figs. 11, 8 and 11, 9). The female 0.62 mm long has a few spinules on the outer rim of baseoendopodite of both of the leg 5 (Fig. 13, 3). In the female 0.70 mm long, the right leg 5 has only two spinules on its central area of the baseoendopodite segment. In the male 0.50 mm long, the innermost seta of exopodite of both of the leg 5 is fairly longer than the exopodite segment (Fig. 14, 6).

Remarks. The present new species resembles *Z. aurelii* Poppe, *Z. intermedius* Nicholls, *Z. sarsi* Nicholls, *Z. serratus* Monk, *Z. caeruleus* Campbell, *Z. schäferi* Klie, and *Z. robustus* Itô in the general appearance of well-developed inner expansion of baseoendopodite of leg 5 of the female. The new species, however, is easily distinguishable from *Z. robustus* by the shape of the first endopodite segment of leg 1 and from the other six species by a characteristic in the baseoendopodite of the female leg 5 that the outer rim is quite short, compared it with the maximum length of this segment.

On the other hand, other differences were detected between *Z. intermedius* and the present new species. In the leg 1, the praecoxa is furnished with long spinules or hairs in *Z. intermedius* (Itô, 1974; see also Fig. 12, 8), but is entirely bare in the new species. The shape as well as ornamentation of the coxa of this leg is also different between them (cf. Figs. 12, 7 and 12, 8). Inner edge of the coxa in question is well rounded, and the outer edge bears a number of very long hairs in *Z. intermedius*, whilst the former is almost straight, and the latter bears some elongate spinules in this new species. These two species are also easily distinguishable from each other by a noticeable difference in the proportion of coxa to basis. The basis of leg 1 in *Z. intermedius* is relatively longer than in the new species and of a narrower appearance. Narrower appearance of the rami of leg 2–leg 4 of *Z. intermedius* would be also considerable as a distinguishing character (cf. Figs. 12, 4, 5, 13, 1, and Itô, 1974, figs. 2, 8, 9, 10). In *Z. intermedius*, the coxal outer edge of leg 2 has hair-like spinules which are comparable with the short spinules in the new species. In the anterior surface of the baseoendopodite of the female leg 5, on the other hand, a spinular row (or close rows) rises from an almost middle portion and extends always obliquely onto the outer base of inner expansion in *Z. intermedius* (Nicholls, 1939; Itô, 1974), though the corresponding spinular row is represented by a short transverse one which does not extend onto the outer edge in the present new species (Fig. 13, 2–3). In addition to this characteristic of the spinular ornamentation, another difference is present between their baseoendopodite segment. Inner two of the marginal setae are short and stout in *Z. intermedius* but not so short and rather flexible in the new species. A marked difference can be found in the leg 5 of the males too; namely, the third and fourth setae of the exopodite are sparsely spinulose in *Z. intermedius* but very densely spinulose in the new species.

Such characteristics found in the fifth leg will be discussed again in the final section.

Type-series. Holotype: female (4-VII-1976; Hirano leg.). Allotype: male (ditto). Paratypes: three females and two males (ditto). Type-locality: Narrow Cape, Kodiak Island, Alaska.

The trivial name is in honor of Mr. K. Hirano of Hokkaido University.

Description of the fourth copepodid female of Z. hiranoi

A copepodid female of the fourth stage which had been paired by the allotypic male was dissected. Segmentations of all the appendages are completely identical with those in the same stage of *Z. robustus* previously reported (Itô, 1976).

Body (Fig. 15, 1) 0.39 mm long, of a very stumpy appearance, consisting of eight somites. Rostrum prominent in dorsal view. Cephalothoracic somite wider than long, apparently widening posteriorly. Separation between first two abdominal somites not clear in ventral view (Fig. 15, 7). Antennule (Fig. 15, 2) consisting of three proximal and four distal segments.

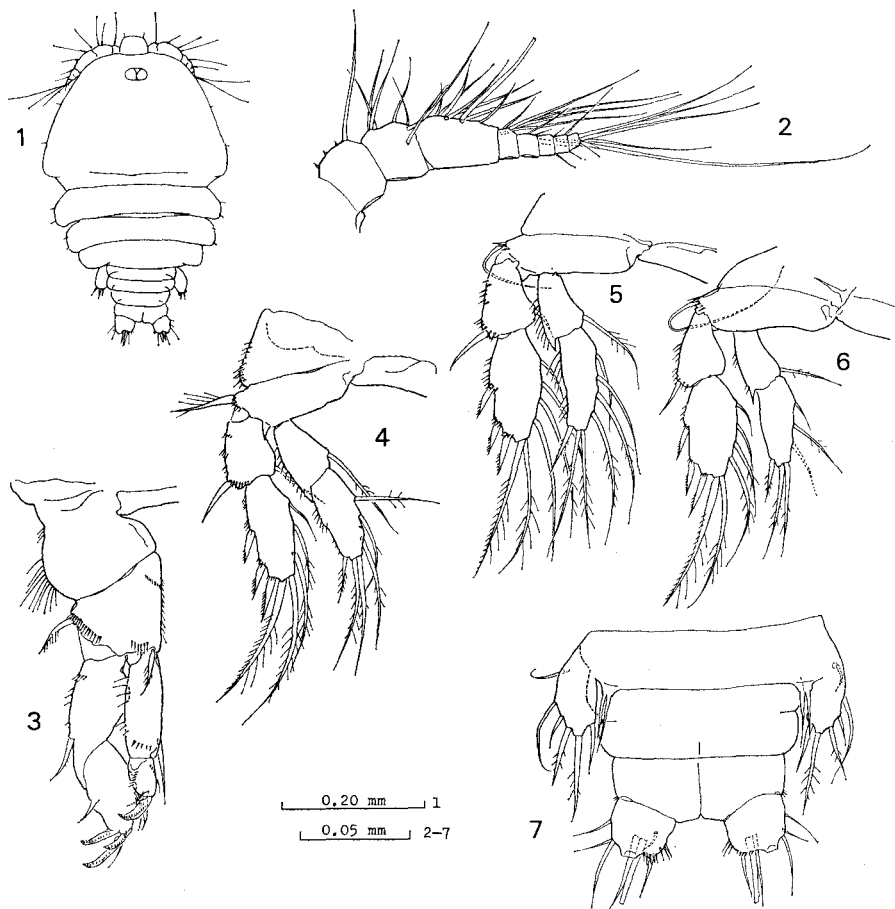


Fig. 15. *Zaus hiranoi* n. sp. Fourth copepodid female. 1, habitus, dorsal; 2, antennule; 3, leg 1; 4, leg 2; 5, leg 3; 6, leg 4; 7, leg 5 and abdomen.

Leg 1 (Fig. 15, 3). Coxa with no spinular row on its anterior surface near distal limit. Coxa and basis subequal in length. Second exopodite segment furnished with one thick seta on the middle of outer edge, three serrate claws and one bare setula on distal edge, and one small seta on inner edge. Second endopodite segment with one serrate claw, accompanied by one spine and a setula, on its distal edge, and with one fine seta arising from a subproximal inner edge. *Leg 2* (Fig. 15, 4). Two vertical rows of spinules occurring on outer side of coxa. *Leg 3* (Fig. 15, 5). Outer seta of basis not very long. *Leg 4* (Fig. 15, 6). Outer seta of basis elongated, reaching the distal end of second exopodite segment. *Leg 5* (Fig. 15, 7) confluent with somite, with two parallel setae arising from a small protuberance which represents the inner expansion of baseoendopodite. Five setae of exopodite differentiated.

Discussion

During the investigation of the present material I noticed that some useful taxonomic characters had so far been disregarded. For example, the setal structure of the exopodite of the male leg 5 is apparently of a certain taxonomic value. Table 1 represents the differences among the four species, *Z. aurelii*, *Z. intermedius*, *Z. hiranoi* n. sp., and *Z. robustus*, which are closely related by a common marked character that the last endopodite segment of leg 1 bears a geniculate spine. These four species are easily distinguishable from each other in those characters present in the male leg 5. The male leg 5 of *Z. caeruleus* Campbell, as far as can be ascertained in his figure (Campbell, 1929, pl. III, fig. 2), is identical with that of *Z. intermedius* in those characters enumerated.

Several differences in the setal structure of the fifth leg are present in the females too. The terminal seta of the exopodite is entirely bare in *Z. robustus*, but is somewhat spinulose in the other three species. Although the fifth (outermost) marginal seta of the segment is always naked in *Z. aurelii*, *Z. robustus*, *Z. hiranoi*, and *Z. intermedius*, the corresponding seta is somewhat spinulose in *Z. spinatus* Claus (see Sars, 1904; Lang,

Table 1. Comparison of the setal structures of the exopodite of male leg 5 among four *Zaus* species. Setal number is counted from the innermost one.

		<i>aurelii</i>	<i>intermedius</i>	<i>hiranoi</i>	<i>robustus</i>
Seta I	with only minute spinules	+	+	+	
	with long hairs as well				+
Seta II	thick	+			
	narrow		+	+	+
	sparsely spinulose	+	+	+	
	almost bare				+
Seta III, IV	sparsely spinulose	+	+		
	densely spinulose			+	+

1965; Itô, 1974) as well as *Z. biunguiferus* Lang (Lang, 1965). In *Z. unisetosus* Itô from Hokkaido, the seta in question is usually spinulose (Itô, 1974), whilst a few examples having an almost bare seta have also been observed. Incidentally, the first seta having long hairs found in the exopodite of the female leg 5 of *Z. robustus* is noteworthy.

On the other hand, the presence of the spine-like sensillae of the first three thoracic somites in *Z. aurelii* seems to be unique within the genus. These 'minor' structures, such as epimeral sensillae and, also, so-called integumental organs to which certain attention is given especially in the calanoid taxonomy (Fleminger, 1973; Mauchline, 1977; Mauchline and Nemoto, 1977), no doubt, are not negligible in the harpacticoid taxonomy either.

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EXPLANATION OF PLATE I

- Fig. 1. Rostrum (*Zaus aurelii*, female).
Fig. 2. First two exopodite segments of leg 2 (ditto).
Fig. 3. Distal two exopodite segments of leg 3 (ditto).
Fig. 4. A pair of leg 1 (*Zaus robustus*, female of S-form).

1-3: scanning electron photomicrograph. 4: light microscope with phase-contrast. Each scale represents 0.01 mm.

